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Stereochemistry of Organic Compounds VI.

On the Optical Rotatory Contribution of Aglycones of Acetylglycosides

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有機化合物の立体化学　Ⅵ

アセチルグルコース及びアセチルグルコサミンのアグリコンの旋光寄与

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概　　要

前報では鎖状糖の C_1 にニトロ基を導入し，鎖状糖の構造の安定性が旋光性に及ぼす影響を調べるため，flexible な炭素鎖をベンジリデン基で架橋し安定な6員環を形成させてその CD, RD, UV, NMR を測定し，報告した。この時，ベンジリデン基の中のフェニル基は不斉中心から遠い位置にあるため，当然フェニル基の遷移が立体配座の決め手となる旋光寄与を示さないが，弱いながらも光学活性となって，CD, RD 曲線上に微細な吸収として現れた。

そこで，本論文では，このフェニル基が光学活性吸収帯を支配する場合の効果を調べるため，アセチルグルコース（Ⅰ）とⅠのアグリコンをフェニル基に変えたもの（Ⅱ），このフェニル基の *p*-位又は *o*-位にフォルミル基を導入したもの（Ⅲ とⅣ）を合成し，その効果を調べた。更に，一般にピラノースでは C_1^* の旋光能が最大で C_2^* の旋光能がこれに続くとされているので，この C_2^* の置換基が C_1^* のアグリコンに及ぼす影響を調べるため，アセチルグルコサミン（Ⅴ）を用いて，それぞれⅢとⅣに対応するフォルミルフェニル誘導体Ⅵ とⅦを合成し，比較検討した。Ⅰ～Ⅶの化合物はすべて *β*-体である。

この結果，Ⅰでは C_1–OA_c による $n \rightarrow \pi^*$ 遷移が 222nm に正の Cotton 効果に，Ⅱでは 266nm に C_1–ph の ^1L_b–band が負の Cotton 効果として現われた。Ⅲの場合は 260～280nm の ^1L_b–band の他に長波長側 320～331nm に *p*–CHO の R–bamd による

弱い負の Cotton 効果と，短波長側 244nm 辺に K-band による吸収がそれぞれ観測された。Ⅳの場合は，フェニル基の ^1L_b-band より長波長側に exciton-splitting 型の正→負の Cotton 効果を示した。これは *o*-CHO の R-band が coupling を起こしたためと考えられるが，この coupling は隣接位 C_2-OA_c によりもたらされたものではない。著者の一人（K. Satsumabayashi *et al.*, *Bull. Chem. Soc. Jpn.*, **44**, 526 (1971)）がすでに報告したように，Ⅳの deacetyl 体が同様の効果を示すことから明らかである。C_1^* につく残りは，環酸素原子であるから結局，この coupling は *o*-formylphenyl 基と環酸素原子との2つの遷移モーメント間の相互作用と考えてよい。

C_2 による影響をさらに確認するため，Ⅴ，Ⅵ，Ⅷについて調べたところ結果は上に述べた考えを支持した。

また，短波長側のデータを必要とすることから極性のある溶媒エタノールが用いられたので，溶媒による影響を取り除くため，ジオキサンを用いて測定可能な領域までのデータを比較した。その結果は上の記述が正しいことを明確にした。

以上総括すると，first Cotton 効果が C_1 の chirality（S-configuration）と一致して負の sign を示すのは，Ⅱ，Ⅲ，Ⅵの場合で，逆転して正の sign を示すのは，Ⅰ，Ⅳ，Ⅴ，Ⅷの場合である。前者はアグリコンが C_1-O に向って対称軸をもつか又はほぼ対称である場合であり，後者はアグリコンが非対称か又は C_1-O に向って対称軸が大きくずれる場合であると考えられる。

今後は，アグリコンとして多くの種類の chiroptical group を導入して裏付けを求めたい。

Stereochemistry of Organic Compounds VI.[1]

On the Optical Rotatory Contribution of Aglycones of Acetylglycosides

In a previous paper,[1] the optical contribution and the solvent effects of C_1–nitrosugars with the rigid structures from C_3 to C_5 have been studied. In that study,[1] the phenyl group showed the vibrational structure on the circular dichroism (CD) curve, but the optical contribution of the phenyl group was not clarified because the phenyl group was far from the asymmetric center.

In this paper, further investigations of the phenyl group and formylphenyl group were carried out and the properties of the chiroptical chromophore were discussed. For that purpose the following seven compounds in Fig. 1 were synthesized.

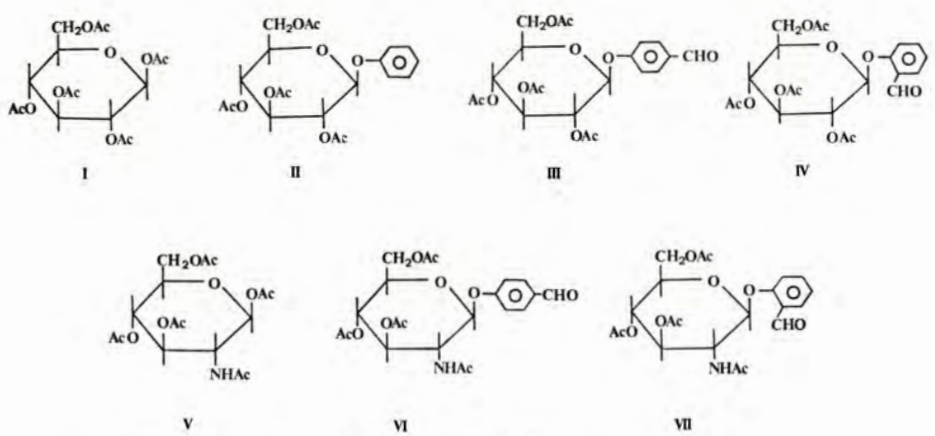

Fig. 1. Structures of Derivatives of Glucoses and Glucosamines.

Results and Discussion

In Fig. 2 are given the CD and UV (ultraviolet absorption spectra) curves of Compounds I, II and III in ethanol. It is shown that Compound I has a positive single Cotton effect with CD_{max} at 222 nm and, as it is clear from the UV curve

of I, this Cotton effect is due to $n \rightarrow \pi^*$ transition at 206 nm of the C_1–O–Ac group. This fact indicates that the sign of the Cotton effect is not in harmony with the C_1–chirality of Compound I with S-type configuration (β–form).

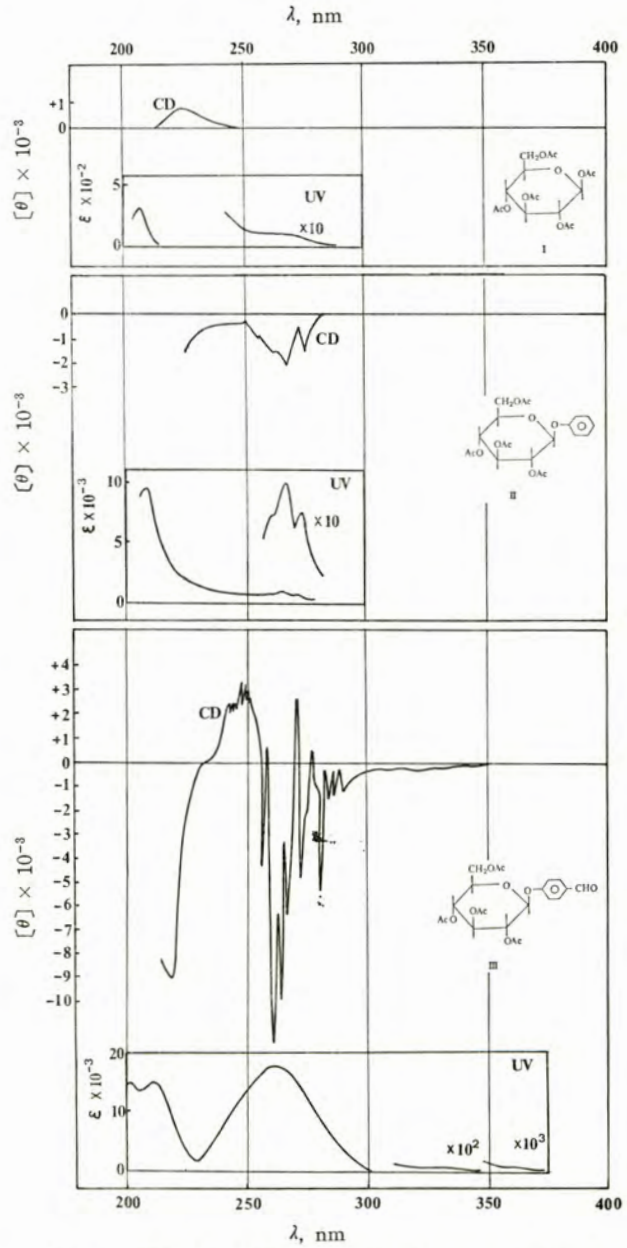

Fig. 2. The CD, UV curves of I, II, III in ethanol.

On the contrary, the sign of the complex Cotton effects of Compound II which shows negative maxima around 266 nm is in accord with the C_1–chirality of Compound II. As is evident from the CD curve of Compound II, the complex Cotton effects show that the ^1L_b bands of phenyl group around 260～273 nm in UV curve are optically active absorption bands.

The CD curves of Compound III in Fig. 2 will be discussed by comparing them with Compound II. First, based on a comparison with the CD and UV curves of Compound II, it was determined that the complex Cotton effects having large amplitudes around 260～280 nm are due to the ^1L_b bands of the phenyl group. The details of these ^1L_b bands have been discussed by H. E. Smith.[4] As may be seen in Fig. 2, besides the complex Cotton effects around 260～280 nm, the CD curves of Compound III show the negative weak Cotton effect around 320～331 nm and the positive strong Cotton effect at 244 nm. It became evident that the CHO group introduced at para-position to the phenyl group are also optically active, and are attributed to the $n\rightarrow\pi^*$ and $\pi\rightarrow\pi^*$ transition brought about through the resonance of the phenyl-carbonyl group. That is, the positive Cotton effect at 244 nm is due to the $\pi\rightarrow\pi^*$ transition and the negative one around 320～331 nm is due to the $n\rightarrow\pi^*$ transition of the CHO group. An important feature of Compound III is that the sign of the first Cotton effect is in accordance with the C_1–configuration.

Figure 3 shows the CD and UV curves of Compound IV which has an ortho-formyl group at C_1. For comparison, those curves of Compound III are shown again in Fig. 3. The most remarkable thing about Compound IV is that the first Cotton effect is positive and the second Cotton effect is negative, and the shape of the curve around these two Cotton effects indicates the exciton-splitting type spectrum. By studying the deacetylated compound of IV we have reported[2] that the signs of two Cotton effects in the long wavelength region are the same as Compound IV. According to this fact, exciton-splitting is not brought about by the C_2–O–Ac group which is the nearest group to the CHO group at ortho-position of the C_1–phenyl group. Therefore, it is caused by the coupling of two transition moments[5] from the ortho-formyl group and from the ring Oxygen. According to H. Meguro *et al.*, the optical contribution of CD and RD is affected by the ring Oxygen of the pyranose, and the chirality of deacetylated phenyl glycosides is explained by the ring Oxygen helicity rule.[6,7]

In order to get more information about the influence of the C_2–group, we have studied the compounds having an acetylamino group at C_2. Figure 4 gives the CD curves of Compounds V, VI and VII. As is clear from the spectra, those of Compounds V, VI and VII show the same patterns as those of Compouns I, III

and IV. It is worth noting that no difference between Compounds VII and IV are recognized in spite of the possibility of NH·····O=C Hydrogen bond[8] between the formyl group and the acetylamino group. This fact shows that it is not possible that the steric interaction due to the C_2-group contributes to the formation of the preferable rotamer.

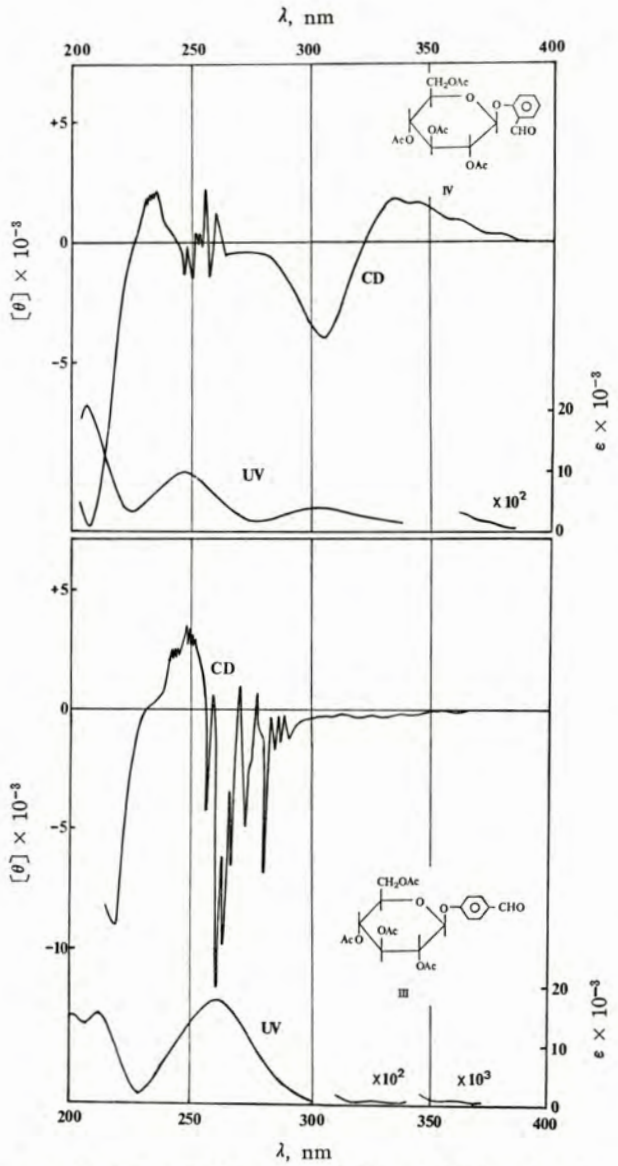

Fig. 3. CD and UV curves of III and IV in ethanol.

All the above spectra were measured in ethanol as the suitable solvent having appropriate solubility of the compounds and not being absorbed itself in a spectral region.

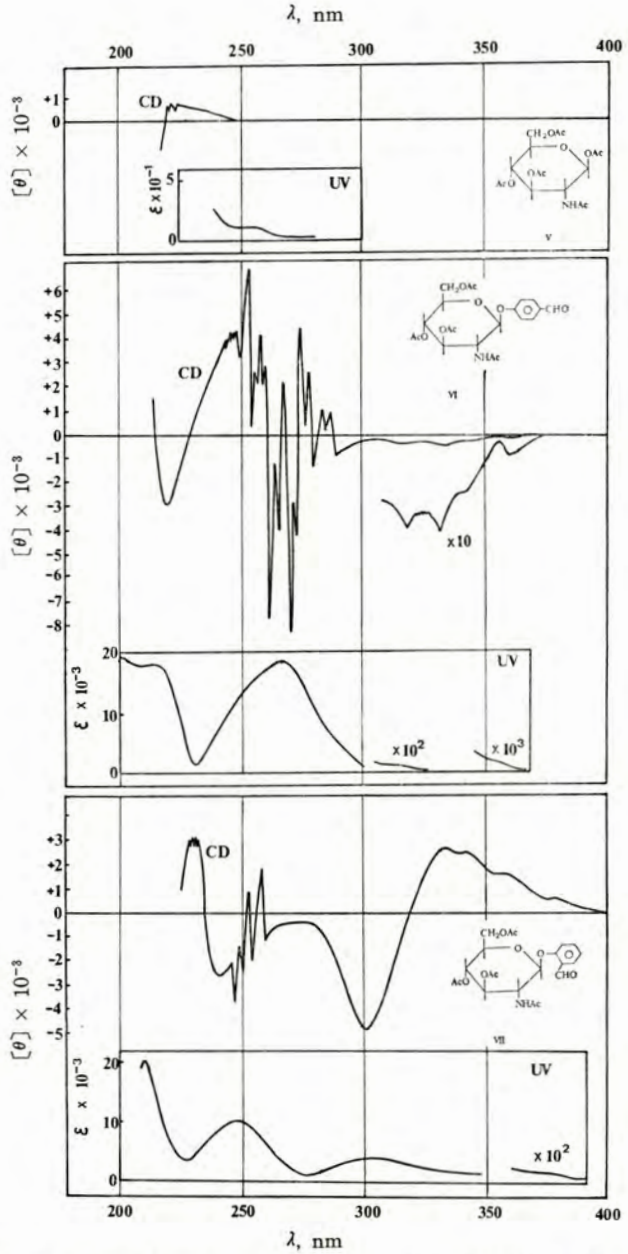

Fig. 4. The CD and UV curves of V, VI and VII in ethanol.

It is reported that the optical contribution is completely different in the polar solvent and in the non-polar solvent,[9] and also the acetylamino group is affected by the solvent.[10] In order to get more accurate information about solvent effects,

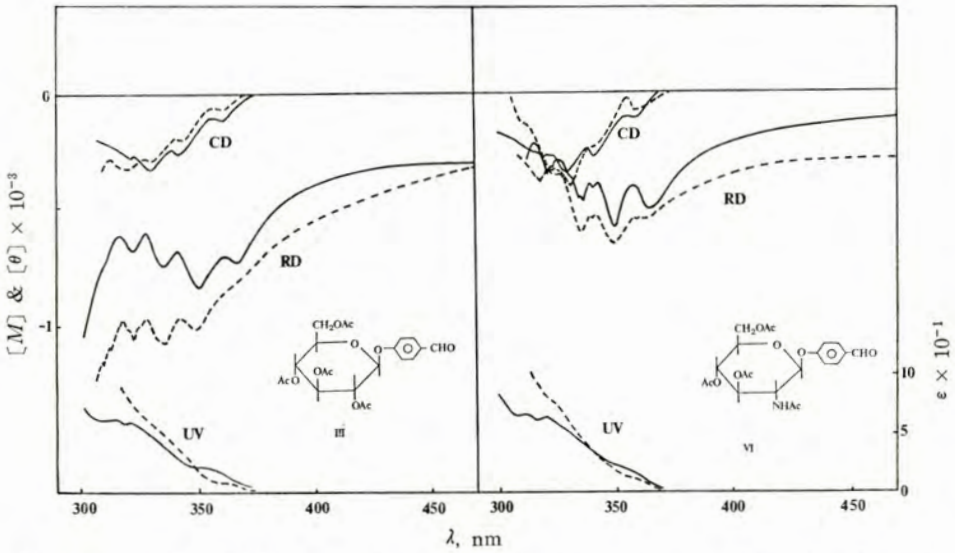

Fig. 5. RD, CD and UV curves of III and VI in dioxane (——) and in ethanol (----).

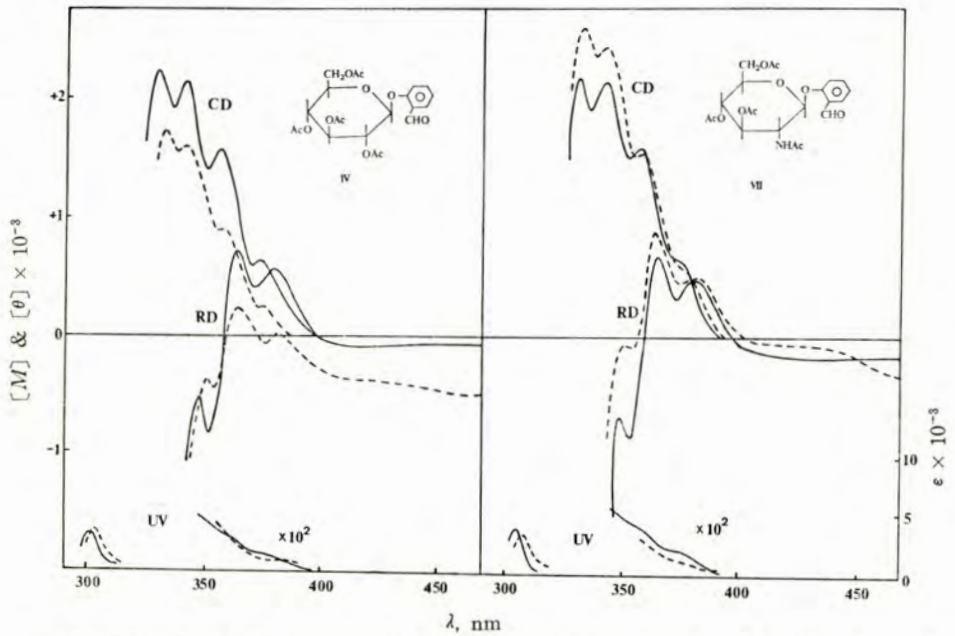

Fig. 6. RD, CD and UV curves of IV and VII in dioxane (——) and in ethanol (----).

all the spectra were measured in dioxane as a non-polar solvent. As seen in Figs. 5 and 6, the CD spectra of Compounds III and VI, and those of Compounds IV and VII are nearly the same while the CD values showed a slight difference in ethanol. Therefore, it is confirmed that the discussion about the Cotton effects in ethanol were correct.

To summarize, the sign of the first Cotton effect is determined by the structure of the chromophore introduced at C_1. In the cases of acetylglucose and acetylglucosamine derivatives, chirality is in harmony with the sign of the Cotton effect when the phenyl and the para-formylphenyl group were introduced at C_1. On the other hand, when the acetyl and the ortho-formylphenyl group were introduced at C_1, the sign of the Cotton effect reverses. It is concluded that the sign of the Cotton effect and the C_1–chirality are brought into agreement in the following cases: when the chiroptical group has a symmetric axis toward the C_1–Carbon, like Compound II, and when the part which contributes to the first Cotton effect is situated in a position which has less contribution than the group next to the C_1–Carbon, like Compounds III and VI. It is also concluded that the sign of the Cotton effect and the C_1–chirality are brought into disagreement in the following cases: when the chiroptical groups do not have symmetric axes, like Compounds I and V, and when the dominant group which attributes to the first Cotton effect is situated in a position near to the C_1–Carbon, like Compounds IV and VII.

Anyhow, it must be admitted that further study will be needed to make clear the cause of the anomaly in rotation.

Experimental

The samples were prepared according to the methods described in the literature. The others were also synthesized in a similar way.

All compounds were confirmed by measurement of the nuclear magnetic resonance (NMR). The NMR spectra were recorded with a JNM-PMX 60 NMR spectrometer at room temperature in chloroform-d with tetramethysilane as an internal reference. The δ values are listed in Table 1.

The Rotatory dispersion and circular dichroism were measured in ethanol and dioxane at room temperature in wavelengths from 200 to 600 nm with a JASCO ORD/UV-5 type optical rotatory dispersion recorder. The ultra-violet absorption was measured with a Hitachi 320 type spectrophotometer at room temperature. The results are shown in Figs. 2—6.

Penta-*O*-acetyl -ß-D-glucopyranoside (Compound I).[11] White needles; mp 131°C. $[\alpha]_D^{20}$ +4° (in chloroform).

Table 1 NMR Data of I-VII (δ, ppm)

Compd	$-COCH_3$		-CHO
I	2.10 1.93	—	—
II	2.07	7.53−6.87	—
III	2.20	8.07−7.33	10.10
IV	2.10	8.10−7.30	10.50
V	2.10 2.00	—	—
VI	2.20 2.07	7.83−7.13	9.87
VII	2.13 1.93	8.00−6.70	10.27

Tetra-*O*-acetyl Phenyl-ß-D-glucopyranoside (Compound II).[12] White needles; mp 122—123°C. $[\alpha]_D^{21}$ −21.8° (in chloroform).

p-Formylphenyl Tetra-*O*-acetyl-ß-D-glucopyranoside (Compound III).[13] Colorless needles; mp 143.5—144°C. $[\alpha]_D^{24}$ −35.9° (in ethanol).

o-Formylphenyl Tetra-*O*-acetyl-ß-D-glucopyranoside (Compound IV).[14,15] White needles; mp 142°C. $[\alpha]_D^{25}$ − 25.0° (in ethanol).

2-Acetamido-2-deoxy-1, 3, 4, 6-tetra-*O*-acetyl-ß-D-glucopyranoside (Compound V).[16] White needles; mp 186—189°C. $[\alpha]_D^{24}$ + 3.9° (in chloroform).

p-Formylphenyl 2-Acetamido-2-deoxy-3, 4, 6-tri-*O*-acetyl-ß-D-glucopyranoside (Compound VI).[17] White needles; mp 220—221.5°C. $[\alpha]_D^{24}$ −32.6° (in ethanol).

o-Formylphenyl 2-Acetamido-2-deoxy-3, 4, 6-tri-*O*-acetyl-ß-D-glucopyranoside (Compound VII).[18] White needles; mp 194—195.5°C. $[\alpha]_D^{25}$ −8.82° (in ethanol).

References

1) K. Satsumabayashi and Y. Nomoto, this Bulletin, **12**, 135 (1983).
2) Y. Tsuzuki, S. Kataoka, M. Funayama and K. Satsumabayashi, *Bull. Chem. Soc. Japan*, **44**, 526 (1971).
3) K. Satsumabayashi, this Bulletin, **2**, 55 (1973).
4) H. E. Smith, J. R. Neergaard, T. de Paulis and Fu-M. Chen, *J. Am. Chem. Soc.*, **105**, 1578 (1983).
5) J. H. Schellmann, *Acc, Chem. Res.*, **1**, 144 (1968).
6) K. Kohata and H. Meguro, *Agri. Biol. Chem.*, **46**, 927 (1982).
7) K. Kohata, E. Otaki, C. Suzuki and H. Meguro, *Nippon Kagaku Kaishi*, 1609 (1982).
8) R. Taylor, O. Kennard and W. Versichel, *J. Am. Chem. Soc.*, **105**, 5761 (1983).
9) T. Połoński, *J. Chem. Soc.* Perkin trans., **I**, 305 (1983).

10) H. Matsuura, K. Hasegawa and T. Miyazawa, *Bull. Chem. Soc. Jpn.*, **55**, 1999 (1982).
11) E. Fischer, *Ber.*, **49**, 584 (1916).
12) H. G. Lantham, E. L. May and E. Mosettig, *J. Org. Chem.*, **15**, 884 (1950).
13) L. Reichel and R. Schickle, *Ann. Chem.*, **553**, 98 (1942).
14) F. Michael, *Amer, Chem. J.*, **1**, 309 (1879).
15) H. Schiff, *Ann, Chem.*, **154**, 19 (1870).
16) K. U. Hofmann, *Helv.*, **12**, 616 (1929).
17) B. Capon, W.G. Overend and M. Sobell, *J. Chem. Soc.*, **1961**, 5172.